Practice Final Chem 14B Winter 2020

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Q1. A 3.00-L reaction vessel is filled with 0.342 mol CO (g), 0.215 mol $H_2$ (g), and 0.125 mol $CH_3OH$ (g). Equilibrium is reached in the presence of a zinc oxide-chromium (III) oxide catalyst and, at 300 ℃, $K_c = 1.1 \times 10^{-2}$ for the reaction $CO\ (g) + 2H_2\ (g) \rightleftharpoons CH_3OH\ (g)$. As the reaction approaches equilibrium, will the concentration of $CH_3OH$ increase, decrease, or remain unchanged?

Q2. Ammonium carbamate ($NH_4(NH_2CO_2)$) serves a key role in the formation of carbamoyl phosphate, which is necessary for the urea cycle and pyrimidine production. At 40 ℃, ammonium carbamate decomposes into ammonia gas and carbon dioxide gas in an endothermic process: $NH_4(NH_2CO_2)\ (s) \rightleftharpoons 2NH_3\ (g) + CO_2\ (g)$ $K_c = 4.2 \times 10^{-7}$

The following changes are to be made to the system; which will increase the concentration of $CO_2$ at equilibrium? (circle all that apply)

I. Adding a small amount of ammonium carbamate

II. Increasing the volume of the system

III. Removing $NH_3$ (g)

IV. Cooling the system

Q3. Lyndon mixes 1.16 mole of A, 1.35 mole of B, and 0.641 mole of C in a one-liter container at a certain temperature. He allows the reaction to reach equilibrium. At equilibrium. the number of moles of A is 1.95. He wants you to calculate the equilibrium constant, $K_c$, for the reaction given the following reaction: $2\,A\,(g) \rightleftharpoons 2\,B\,(g) + C\,(g)$

Q4. The overall dissociation of oxalic acid, $H_2C_2O_4$ is represented below. The overall dissociation constant is also indicated. a) What volume of 0.400 M NaOH is required to neutralize completely a $5.00 \times 10^{-3}$ mol sample of pure oxalic acid. b) Give the equations representing the first and second dissociations of oxalic acid. Calculate the value of the first dissociation constant, $K_1$, for oxalic acid if the value of the second dissociation constant, $K_2$, is $6.40 \times 10^{-5}$. c) A strong acid is added to a 0.015 M solution of oxalic acid until the pH is 0.5. Calculate the $[C_2O_4^{2-}]$ in the resulting solution. (Assume the change in volume is negligible.)

$H_2C_2O_4 \rightleftharpoons 2H^+ + C_2O_4^{2-}$, $K = 3.78 \times 10^{-6}$

Q5. The acetic acid/acetate buffer is a common buffer used in chemistry. Suppose you have a 100. mL solution of this buffer at 25 ℃ where the concentrations of acetic acid and acetate are both 0.20 M. (a) What is the pH of this solution? (b) Calculate the change in pH when 50. mL of 0.10 M NaOH is added to the buffer solution versus an equivalent volume of water at the same pH. (c) What can you conclude about the purpose of a buffer?

$$CH_3COOH\ (aq) + H_2O\ (l) \rightleftharpoons CH_3CO_2^-\ (aq) + H_3O^+\ (aq) \qquad K_a = 1.8 \times 10^{-5}$$

Q6. Dr. Lavelle gets an ant bite on his foot. On doing his research he realizes that formic acid, $HCOOH$, from the ant bite is causing a burning sensation on his foot. He is interested in finding the pH of a 0.065 M solution of formic acid given $K_a$ ($HCOOH$) = $1.80 \times 10^{-4}$.

Do not make approximations in your calculations.

Q7. In a microwave oven, radiation is absorbed by water in the food and the food is heated. How many photons of wavelength 4.50 mm are required to heat 350. g of water from 25.0 ℃ to 100.0 ℃, assuming that all the energy is used to raise the temperature?

Q8. A 1.00 kg copper pot is heated on a stove. You place a 50 g cube of ice at 0.0 ℃ in the pot and quickly take it off the burners. After some time, you take the temperature of the now-melted ice and find its temperature be 20.0 ℃, and that the temperature is not changing. What was the initial temperature of the copper pot? Assume no heat is lost to the surroundings.

$C_s$ (copper) = 0.39 J/g.℃

Q9. As discussed in class the burning of natural gas is a common energy source in power plants to generate electricity. Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, $CH_4$. Calculate the reaction enthalpy per mole of methane combustion using the data given below. Is the reaction exothermic or endothermic?

| | |
|---|---|
| $\Delta H_B$ (O-H) = 463 kJ/mol | $\Delta H_B$ (C-H) = 412 kJ/mol |
| $\Delta H_B$ (C=O) = 743 kJ/mol | $\Delta H_B$ (O-H) = 496 kJ/mol |

Q10. Initially, a sample of ideal gas at 412 K occupies 12.62 L at 0.6789 atm. The gas is allowed to expand to 19.44 L by isothermal, reversible expansion. Calculate $\Delta S_{tot}$, $\Delta S$, and $\Delta S_{surr}$ for this pathway.

Q11. Suppose a certain chemical reaction has a $\Delta G° = +10.0$ kJ/mol at 25 ℃. If the temperature is increased to 40 ℃, what is the equilibrium constant of the reaction? $\Delta H° = + 2.5$ kJ/mol

Q12. A balloon is inflated to its full extent by heating the air inside it, using $6.3 \times 10^8$ J of heat. The initial volume is $2.5 \times 10^3$ L. Assume that the balloon expands against a constant pressure of 1.0 atm. The change in internal energy is $5.8 \times 10^8$ J. What is the final volume of the balloon? (101.3 J = 1 L atm)